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EPIDEMIC MALARIA

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CONSTRUCTION WORKS.

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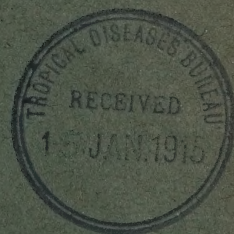
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(Paper presented to the Society of Tropical Medicine and Hygiene,
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EPIDEMIC MALARIA AND CONSTRUCTION WORKS.

By A. G. H. SMART, M.B., D.T.M. & H.,

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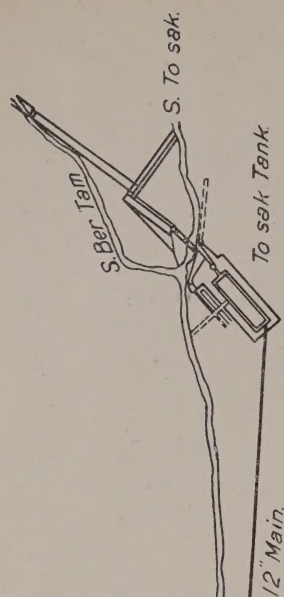
Received September, 1914.

While I was in Kedah, during the early part of this year, the State had under construction a water scheme, by which certain streams at an elevation of about three hundred feet were being tapped, and a service line was being brought down to Alor Star, the capital, a distance from the head works by road of about twenty miles.

The plan attached shews the different streams, viz.:—the Sungei Terjun and the Sungei Bertam, which united on a level with the coolie line marked "A," to form the Sungei Wang. There were two large settling tanks nearly completed, each with a capacity of four hundred thousand gallons, and a large pipe took the water from each, these pipes joining practically where the streams met to form the main going down to Alor Star.

The Terjun is the more important of the two streams from the point of view of these notes. It followed a fairly direct course through a rocky channel of quartzite formation, with steep hill slopes covered with jungle coming down on either side.

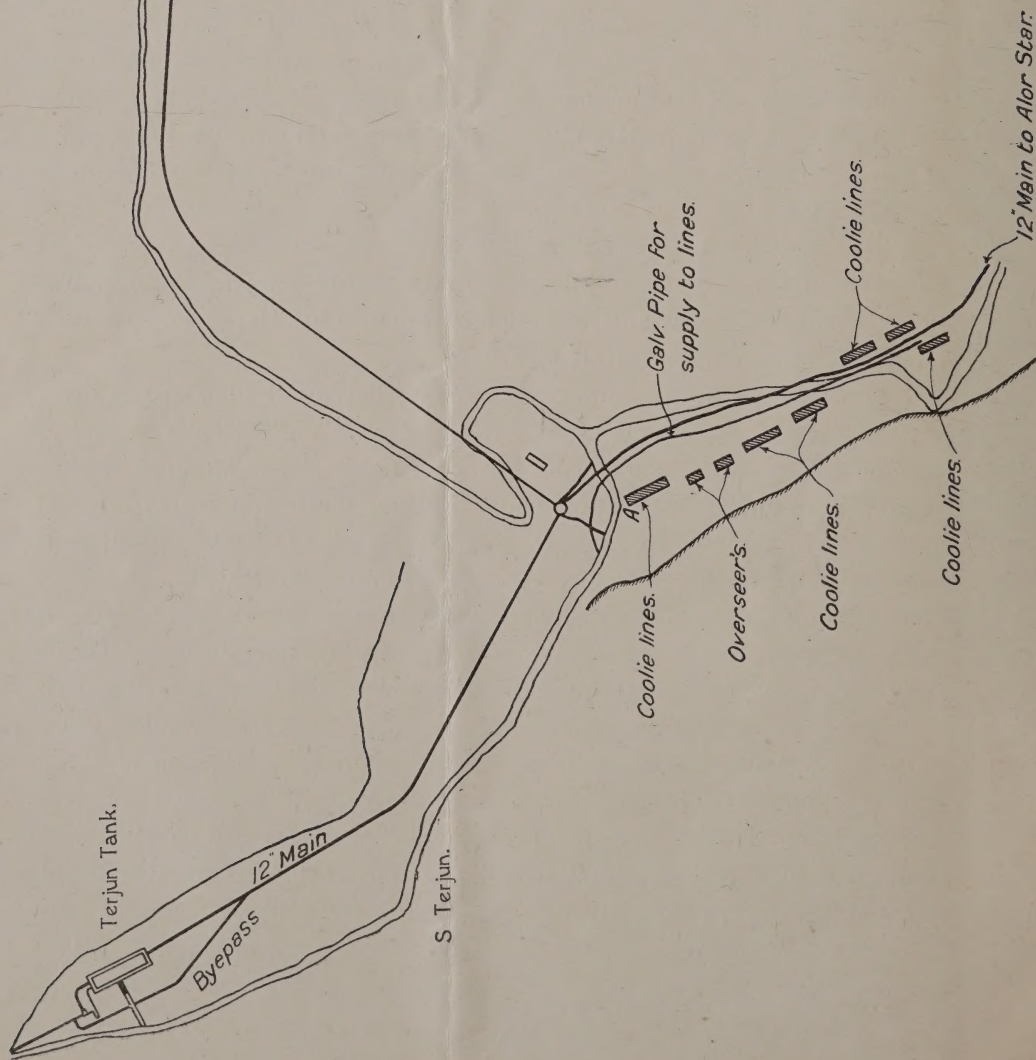
Construction work commenced in May, 1913, and a labour force was brought to the site at the head of the Sungei Wang. In the beginning the health was good; and on the 28th June, out of one hundred coolies, eleven were unfit for work, of whom five had malaria, probably infected before arrival. On July 11th, the health was reported not so good, with an undue percentage of sick. On the 30th of September, the labour force numbered two hundred and eighty coolies, and the percentage of sick was only three and a half, not all malaria, there being a certain amount of ankylostomiasis present. All the coolies were supplied with mosquito nets during September. On the 7th of November, out of three hundred and fifty coolies, only seven were unfit for work, and of these five had malaria; but on the 30th of December, the State Surgeon reported on his visit that the health was "nearly as bad as possible." Out of a total of three hundred coolies, only half this number could turn out to work, practically all the sickness being due to malaria. In



ALOR STAR WATERWORKS.

SKETCH PLAN OF COOLIE LINES.

Scale 200 feet to one inch.



addition, four cases of cholera occurred during this month. On the 16th of January of this year, out of the two hundred and eighty coolies examined, ninety had fever; in one Tamil bangsal fifty out of ninety had a temperature above normal. On the 21st of January, forty cases of malaria from these coolies were admitted to the General Hospital at Alor Star.

The following shews the monthly incidence of malarial admissions into Alor Hospital:—

1913—May	...	...	...	...	0
June	...	...	...	...	0
July	...	...	...	...	5
August	...	...	...	...	0
September	...	...	...	...	0
October	...	...	...	...	2
November...	...	...	...	...	0
December...	...	...	...	...	3
1914—January	...	...	...	...	61
February	...	...	...	...	18
March	...	...	...	...	18

The different infections seen were as follows:—

Benign Tertian	...	...	...	48 cases.
Subtertian	...	...	...	34 „
Quartan	...	...	...	2 „
Type not diagnosed...	...	...	...	24 „

A considerable number had mixed infections, but what percentage was not recorded.

The following shews the monthly rainfall at Alor Star, and Tanjong Pau, and Sungei Wang respectively:—

1913.	Inches.	Inches.	Inches.
May	14·33	10·08	—
June	12·63	11·08	—
July	8·19	7·05	7·12
August	6·64	8·09	6·88
September	12·67	10·56	11·78
October	11·19	13·70	15·90
November	8·41	8·08	10·64
December	6·25	5·42	7·63

1914.						
January	...	0.18	...	0.19	...	1.15
February	...	0.30	...	1.07	...	1.40
March	...	1.85	...	2.59	...	0.05

Alor Star is about sixteen miles distant in a direct line from the head works, and Tanjong Pau six miles.

On my first visit to the head works on the 28th January, 1914, there were six coolie lines situated on each side of the river, as shewn in the attached plan. Following the line of the river, the bangsal marked "A," was about 500 yards from the dam, where the river was diverted into a large concrete settling tank. The course of the stream had not been interfered with, but the water was very low, while there were many side-pools forming potential and actual mosquito breeding places, especially in the stretch of river between the dam and the coolie line marked "A." Towards the end of December, several cases of cholera had occurred amongst the coolies, so, in order to obtain a safe supply of drinking water, the river was tapped well above the coolie lines, and water brought down in a two-inch service pipe, with stand pipes attached at intervals. In the stretch of river from the dam down to the coolie lines, the following larvæ were found at this visit:—

Anopheles leucosphyrus (DÖNITZ), in a pool at the edge of the stream.

Anopheles kochi, in a stagnant pool at the edge of the stream.

Anopheles sinensis, in an algæ covered pool.

Anopheles maculatus, at the edge of the running stream.

Anopheles karwari, at the edge of the running stream.

Uranotania campestris, associated with *Anopheles maculatus*.

In the Sungei Bertam, within a short distance of the coolie lines were found the larvæ of *A. karwari*.

The small service pipe ran past and close to the coolie lines as shewn in the plan. It was joined up in short lengths and some of these joints leaked, small pools being formed at such sites. The larvæ of *A. maculatus* were obtained from these pools in large numbers. Pools were also produced at the different stand-pipes where the coolies drew off their water supply, such being contaminated with organic refuse, washings from cooking utensils, etc. No anopheline larvæ were found there. For several hundred yards below the level of the coolie lines the stream was also examined for anopheline larvæ, with a negative result. The

larvæ were identified by their own special characters; in a number, identification was confirmed by the respective imagines which hatched out, including that of *A. leucosphyrus*. The specimens of the latter found on this visit were taken from a pool in running water at a site just above the dam. The larvæ of *U. campestris* are commonly associated with those of *A. maculatus* and *A. karwari*, and Dr. FINLAYSON, of Singapore, has pointed out previously the significance of this, namely, that where such larvæ are found, although the larvæ of either of the anophelines may not be caught at any particular time, such a site requires to be carefully watched. The larvæ of *U. campestris* is rather slender, with a light brown body and a small black bead-like head, and is readily recognised with the naked eye, a point which increases the practical value of this observation.

The pools at the leaking joints of the small service pipe were easily dealt with, but conditions similar to those described above, were found prevailing in the stream on three subsequent visits. On my fifth visit, when I was accompanied by Dr. STANTON, we found that the stream had been cut off from the dam, and diverted into the tank mentioned above, and that although a certain amount of overflow from the tank was returning over the spillway into the original bed, the latter for a long stretch below the dam was nothing but a series of shallow pools containing decomposing vegetation, floating algæ forming a dense scum over the surface of the pool. Only the larvæ of *Culex ager* (GILES) were found in these pools, in contrast to the larvæ obtained from the same site before the stream had been cut off; in the stream just above the dam were obtained in numbers the larvæ of either *A. maculatus* or *A. karwari*. In a small jungle pool, fed by a spring, we obtained *A. maculatus* (in numbers), *U. campestris*, *A. leucosphyrus* (one male bred out later), *Lophocerotomyia barkeri* (one male and one female hatched out), and *Culex concolor*.

REMARKS.

STANTON¹ states that *A. leucosphyrus* is met with infrequently in the Malay Peninsula, and THEOBALD² does not include the Malay Peninsula as a habitat. JAMES and LISTON³ mention that they have not seen a specimen for some years in India. DANIELS⁴ writing on the breeding grounds of *Culicidæ*, states that the mosquito is found in cut bamboos,

but is found more commonly in other places. LEICESTER⁵ found it in jungle streams, but also described it from "a large series bred from larvæ, taken from open bamboos and pools in jungle," and Colonel ALCOCK,⁶ writing in the *Journal of the London School of Tropical Medicine*, gives as the habitat of this mosquito, India, Ceylon, and Sumatra only.

The conditions found shewed clearly how particular *A. maculatus* and *A. karwari* larvæ are as to their breeding places. As pointed out above, no such larvæ were found at any site where the water had become contaminated, and yet they could be obtained in numbers in identically similar sites where the water had remained pure perhaps a few yards away from a contaminated pool.

This is well brought out in the case of the small pools at the leaky joints in the service-pipe to the coolie lines, one pool swarming with these larvæ and the next being left severely alone. This is a common experience with these larvæ.

In one instance these were found in a small valley, with rather steep sides, below a Chinese graveyard in Singapore. There were a few squatters' houses at the head of this valley, and these people had tapped some springs at their houses to form wells. Dr. FINLAYSON went over this site last September, and the only anopheline larvæ then found were those of *A. sinensis* breeding in some duck-ponds. No anopheline larvæ were found at this time in the streams formed by the overflow from the wells referred to above, nor on a subsequent inspection while the squatters were living in the valley. But these squatters were turned out about the end of last year and the valley became uninhabited. In May, 1914, Dr. FINLAYSON recovered from this site larvæ of *A. maculatus* associated with those of *U. campestris*.

Reverting to the Sungei Wang conditions, it was also interesting to find *A. maculatus* breeding in the pools referred to, where the pipes leaked, shewing, as it did, that the water coming through had not become altered in any way from the raw river water. A chemical analysis of the water from the Sungei Terjun is shewn as below :—

Colour in 2ft. tube	...	...	clear, white.
Taste ...	...	...	nil.
Smell ...	...	...	nil.
Chlorine	...	...	0.4.
Total solids	...	...	5.0.

Oxygen consumed by organic matter

in four hours	...	...	0.075 per 100,000 parts.
Free ammonia	...	...	trace.
Albuminoid ammonia	...	...	0.002.
Ammonia from nitrates	...	...	0.010.
Ammonia from nitrites	...	...	nil.

With reduction in the number of breeding places, as had occurred during my later visits, it is worth noting how certain remaining sites, previously only scantily occupied, became almost overcrowded, and larvæ, mutually uncongenial under more favourable conditions, became associated in very circumscribed sites. This was seen in the conditions found in a small jungle pool, referred to above, where *A. maculatus*, *A. leucosphyrus*, *U. campestris* and *L. barkeri* were found together with, in addition, the larvæ of *C. concolor*, which latter readily devour smaller larvæ, and would be the natural enemy of such.

The Sungei Terjun became very low in December, and this fall must have taken place about the beginning of the month in order to fit in with the cycle started, which would produce such a large amount of malaria among the coolies towards the end of the month and in the first half of January. It is difficult to attribute this reduction in the volume of the stream to natural conditions entirely, although later this would be justified. The rainfall at the head works in December stopped on the 24th of the month, and the total for the succeeding three months, as can be seen from the table, only amounted to 2.60 inches.

The catchment area for the Sungei Terjun had not been wholly surveyed when I was in Kedah, but the rainfall in this area would not be markedly different from that at the head works, and the latter amounted to 7.63 inches for December up to the 24th.

It is worth noting, however, that the mean minimum temperature for December, viz., 78.61, was 4.65 degrees above the average of the other eleven months from May, 1913, to April, 1914. It is likely that a constantly high temperature has a marked effect in hastening the development of the malaria parasite in the mosquito, and is also favourable to the increase of the parasite in men.

By the end of March the head works had been completed and the labour force disbanded; but had the drought not broken by the end of March, as it did, and construction not been completed, work could

only have been carried on under very trying conditions, and very little could have been done to improve the unhealthy condition of the place in so far as the Sungei Terjun was concerned. WILSON,⁷ in a recent article on the suppression of mosquito breeding places, dealt with this type of breeding ground. He mentioned that the "hollows formed by the action of running water and stones on the surface of rocks in river beds form ideal breeding grounds for mosquitoes," and says that the water-holding capacity of such should be destroyed in malaria infected areas, this being accomplished either by filling in or by blasting.

In the case of the Sungei Terjun such measures, from the wide, irregular and ill-defined nature of the channel, would not have been effective or practicable. The anopheline larvæ found were breeding, not only in pools hollowed out of rock but in the edge of the running stream itself for a long stretch above and below the dam, wherever a few dead leaves, stones or other débris afforded even the slightest amount of shelter.

I am indebted to Dr. FINLAYSON, Government Pathologist, Singapore; Dr. STANTON, of the Institute for Medical Research, Kuala Lumpur; Dr. HOOPS, State Surgeon, Kedah; and Mr. GORMAN, State Engineer, Kedah, for much assistance and information.

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